Chapter

Innovations in Active Education Techniques: Team Based Learning, Flipping the Classroom, and Think-Pair-Share

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Abstract

Team-based learning, flipped classroom, and think-pair-share are active learning pedagogies used commonly in undergraduate medical education today. They are based on constructivist learning theory and are effective to use to actively teach foundational knowledge to medical students. They also help students work on team dynamics, critical thinking, and clinical knowledge application. These techniques can be employed without expensive technology or special training. Medical education was grossly affected by the COVID-19 pandemic and the inability to assemble in person. These educational techniques all allow for enhanced and active remote learning. With the amplification of remote education delivery during the pandemic, it is easy to see how we can use these techniques to spread foundational medical education more equitably across the globe.

Keywords: undergraduate medical education, active learning, team-based learning, flipped classroom, think-pair-share

1. Introduction

Medical students have become increasingly apathetic to traditional lecture-based teaching methods, particularly as they fail to engage the attention of the learners and have been described as an inferior pedagogy with respect to the development of critical thinking skills [1–3]. Indeed, student concentration is well known to shortly dissipate during lecture time [4]. As a result, non-compulsory lecture-based curricula receive poor classroom attendance and overreliance on third-party educational or other external resources. Further, as compelling evidence with respect to important factors such as failure rates has been put forward, the inferior nature of lecture-based teaching pedagogies in the science, technology, engineering, and math (STEM) fields of study relative to active learning pedagogies has been revealed [5, 6]. Active learning methods emphasize the application of information during class time. Such

problem-solving skills promote higher-order thinking in the Bloom's taxonomy. In fact, evidence show that lecture-based delivery of information is outdated and inefficient. Active learning is a superior method for delivering content in the STEM fields [5]. Further, it may no longer be appropriate to use lecture-based teaching as the comparative standard for teaching efficacy, but rather that different active learning modalities should be compared to each other [6].

Active learning models such as cooperative, team-based learning (TBL), and flipped classroom (FC) pedagogies have been developed to address the inadequacies of lecture-based teaching as they strive to eliminate the ineffectiveness of passive learning [7, 8]. Indeed, many medical schools have revised their curriculum to emphasize active learning pedagogies [9, 10]. TBL is a small group format that highlights knowledge application. FC settings reverse the traditional lecture-homework learning model that has dominated education for years and promotes student engagement and learning [11, 12].

Cooperative learning is an active strategy that has been shown to promote student engagement and learner satisfaction [8, 13, 14]. Its successful implementation requires strong interpersonal skills and peer teaching. One type of cooperative learning pedagogy called think-pair-share (TPS) was developed by Lyman and colleagues [15] and has been successfully implemented in healthcare education [16]. TPS is a 3-pronged approach that promotes individual, cooperative, and full class input.

Although these active learning platforms represent promising teaching pedagogies for increasing medical student engagement and acquisition of higher order learning skills some challenges remain. This includes variations in the degrees of improvement of learning outcomes relative to traditional lectures as well as continued student engagement and in-person attendance [10, 17–19]. Thus, in and by itself, the active learning is not necessarily sufficient to address issues such as engagement and attendance.

This chapter will discuss and describe TBL, FC, and TPS as active and progressive educational pedagogies. Descriptions of practical application of each of these strategies will be followed by specific pandemic-stimulated remote learning lessons learned. The technology required to use these techniques will be discussed and specific challenges of special populations and unique education delivery challenges will be reviewed and examined.

2. Educational pedagogies used to activate learning in medical school

2.1 Team-based learning (TBL)

2.1.1 Literature review & learning theory

TBL is a small group format that highlights knowledge application. TBL follows the principles of constructivist educational theory [20]. Constructivist theory was developed from cognitive learning theory and postulates the following four main concepts. Firstly, the teacher is a guide to the educational content and a facilitator for the students. Secondly, learning is active and should employ small group formats. Thirdly, teachers are expected to highlight and explain the inconsistencies between students' foundational knowledge and future experiences. Finally, students should have time to reflect on their learning experiences [21].

In TBL, students are expected to prepare for the application exercise independently and this initial knowledge is tested at the start of the TBL session through an Individual Readiness Assurance Test (IRAT). Students are then broken up into assigned small groups and the same knowledge is tested in the Group Readiness Assurance Test (GRAT). Students are then brought back together for a review of the assurance test material before they are again sent into their assigned groups to complete the Application Exercise (AE). After the application exercise is complete, the large group is brought back together to review the AE. TBL is favorably reviewed by most students and faculty and multiple studies have noted that it has equivalent teaching efficacy to lecture and helps increase test grades of lower performing students [22].

The practice of medicine involves complex knowledge processing, application, and integration. Simple regurgitation of facts will not lead to the necessary skills that students must learn to practice clinical medicine. These critical thinking skills are not easily taught in passive, lecture-based formats. Classically, medical schools have used passive techniques to assist students' obtainment of foundational knowledge during the initial phase of school followed by a precepting environment during latter phases of medical school when students join the healthcare team to deliver patient care. In this way, students both observe the clinical reasoning and knowledge application and begin to practice this skill themselves. TBL allows educators to introduce concept integration and critical thinking skills in a small group format [23]. TBL can be used with an in-person or remote design; synchronously or asynchronously. A single professor or a small group of educators can efficiently teach a very large number of students using TBL making this pedagogy one of the easiest to access regarding limited resource settings. There is no specific technology that is required to run a complete and successful TBL session, though this chapter will address how TBL can use technology to facilitate active learning in a remote setting.

2.1.2 Practical application & examples

TBL is used in our school's curriculum longitudinally throughout the first semester of the first year of medical school. 18 separate sessions are held over the course of almost 5 months with the goal of applying foundational medical knowledge clinically. At the start of each week, our students have an introduction to the clinical subject matter. Throughout the week students have a variety of lectures and active learning covering the foundational knowledge that supports the clinical case. On the last day of the week, the students go through the TBL session.

A best practices specific example would progress as follows:

- ***Monday***: A 30-minute introduction to cystic fibrosis (CF) delivered jointly by a physician and PhD scientist followed by a 20-minute interview with a patient living with CF.
    - Learning objectives: cell membrane and channel biology, a clinical overview of CF, and a review of the genetics related to CF
- Foundational content (during the week):
    - Osmosis

- Carrier-mediated transport
- Cell structure, diffusion, and transport
- Genetic patterns of inheritance

- ***Friday:*** The two-hour TBL session is run by three to four educators including a clinical physician and the relevant PhD science content experts.
  - IRAT – students answer multiple choice content individually on the week's content
  - GRAT – immediately after the IRAT in a group of 6–8, students answer identical questions, receiving real-time feedback when they give the correct answer
  - Debrief – the educators go over any questions that had a low number of correct answers once students were in their small group
  - AE – students work through a clinical case, answering a variety of multiple choice and short answer questions as they follow a case of a patient with cystic fibrosis.
  - Final debrief – educators go through each question of the AE to verify that students have accurate learning and application of clinical concepts.

2.1.3 Covid-19 pandemic effects & remote learning & technology usage

The COVID-19 pandemic grossly affected the delivery of undergraduate medical education in the United States (US). Overnight classes were canceled, and all foundational curriculum delivery was made remote for a year. One of the excellent aspects of TBL is the ability to implement this pedagogy remotely. TBL is incredibly flexible, and with a modicum of technology use can be used in a robust fashion without student/faculty physical proximity.

To deliver a TBL AE remotely, there must be a way for students to answer questions and for faculty to review answers contemporaneously. There also needs to be a way for students to communicate (ideally video-enabled) in a small group, and with the entire class. In our experience, we found that we used a content delivery and a video communication platform concurrently. There exist online platforms specifically for TBL, and our institution used InteDashboard™. The downside of commercial products such as this is the monetary expense. The upside is that they are designed to facilitate the educator in both designing and delivering an AE. Free platforms such as Google Forms could be used in low-resource settings. A concomitant video-enabled communication platform is then employed to allow for small group work and large group collective review with the instructors. Common products used are Zoom and Webex though free products exist such as Google Hangouts, Slack, and Skype.

2.1.4 Unique challenges of TBL

TBL can be a challenging pedagogy both for the faculty and the students. While it is usually rated higher than lecture-based teaching it can take students multiple

sessions to be comfortable with this educational delivery format [24]. Faculty often need hours of training in TBL design and delivery before it can be performed satisfactorily. Creating original TBL cases can introduce a large burden on faculty, and this can be a barrier to using TBL repeatedly throughout a curriculum [25]. We suggest using open-access medical information such as MedEdPORTAL (https://www.mededportal.org/) to access pre-existing TBL cases significantly decreasing the initial time investment required when introducing TBL to a curriculum.

When done well, TBL will push students to stretch beyond memorization into critical thinking. Clinical cases also often introduce elements of ambiguity, ethics, and clinical uncertainty and this can make students uncomfortable, though we argue that this is exactly what medical students need to become competent physicians who lead teams of healthcare professionals.

2.2 The flipped classroom (FC)

2.2.1 Literature review & learning theory

The flipped classroom (FC) pedagogy involves a combination of pre-assigned, independent, asynchronous content and dependent, synchronous teaching [26]. The traditional lecture is often transformed or replaced by content that is expected to be reviewed prior to synchronous, interactive sessions where faculty may go over a case, model problem solving, and in general applying the concepts covered in the assigned pre-work. FC has been shown to increase student motivation and satisfaction with curriculum when compared to classic lecture, and it is at least as effective in teaching material when compared to more passive pedagogies [17]. FC, like TBL, is based on constructivist learning theory.

Flipped classroom settings reverse the traditional lecture-homework learning model that has dominated education for years. Rather, the flipped model involves pre-session learning (i.e. video or reading) followed by class, active learning (i.e. problem solving or case study). When combined with Audience Response Systems (ARS) such as Poll Everywhere® (PE), the flipped classroom has been shown to promote student engagement and learning [11, 12]. ARS allow teachers to synchronously question their students during education delivery and analyze these results. PE is a specific ARS that allows for the embedding of polls and questions into a PowerPoint lecture with immediate analysis. Although the flipped classroom model represents a promising teaching pedagogy for increasing medical student engagement and acquisition of higher order learning skills some challenges remain. This includes variations in the degrees of improvement of learning outcomes relative to traditional lectures as well as continued low attendance and student engagement [10, 17–19]. Thus, in of and by itself, the flipped model is not necessarily sufficient to address issues such as attendance and engagement.

2.2.2 Practical application & examples

The first step to creating an FC active learning session is to translate or replace the lecture material with content that can be studied by the learners prior to attending a synchronous session with the professor. This takes a different skill set than delivering a conventional lecture. In the addition, modern learners are often not satisfied with preparatory material being all reading from a book. This introduces multiple different challenges for educators. First, teaching a video is different from teaching to an audience. When teaching to an audience, student comprehension is readily apparent to the lecturers

and additional opportunities to rephrase difficult concepts may be pursued. In addition, one may employ engaging with the students as a means of transitioning between concepts. Second, utilizing video editing software to make the video short and concise is critical. This software allows educators to remove unintended gaffes or poorly expressed concepts.

A best practice, specific example of the process of converting a 50-minute lecture on hemodynamics into short videos is discussed in next two paragraphs. First, the lecture comprised of 36 slides was subdivided into the main fundamental concepts such as resistance to flow, blood flow, and regulation of vessel compliance. Then, each slide was evaluated for [1] the placement or flow of information in the slide, [2] potential ambiguity in the written text, and [3] figure quality. This process led to the clarification of inexplicit text previously expounded upon during lecture and the inclusion of more informative and straightforward figures. A script was then created of the information to be discussed on each slide using concise phrases that were audibly rehearsed and reworked to better represent the lecturer's instinctive spoken word choice. While the initial purpose of using a script was to create a concise and effective video, an unintended benefit includes having a well-developed work product should the video require future additions or modifications. In addition, students greatly appreciate using the script as an additional study aide to facilitate comprehension of the video content.

When making the video, there are many software options, and our institution uses Panopto. While the explicit software used is not critical, look for intuitive platforms that are not overly complicated if creating content without professional assistance. First, to create high-quality audio, use a headset with a noise-canceling microphone to reduce ambient noise. Second, when interacting with the PowerPoint slide, use the laser pointer option to focus the viewer's attention on specific text or figures on the slide. Third, consider enabling the camera on your computer to video yourself discussing the slides. This option affords the students an opportunity to develop a personal connection with the lecturer even though it's not a live connection. Fourth, remember the editing process will help you achieve a high-quality, short video with accurate and concise descriptions. When making the video, if you misspeak, pause to create a time gap of 1–2 seconds, and then try again. During the editing process, the bloopers can be removed such that an hour-long unedited video may be pared down to a 5–10 minute polished video. Finally, utilize the pause function in your video software. Even using a script, it can be difficult to seamlessly describe many high-yield concepts on a slide. Alternatively, you can focus on one concept at a time by utilizing the pause function between concepts to reset your attention in the script and on the slide. These pauses are easily removed during the editing process.

Once the lecture content is converted to short videos to be previewed by students, the time allotted for the lecture can be utilized for an active learning session when the students can apply the knowledge learned from the videos. Our institution uses an ARS called Poll Everywhere that allows students to answer questions via a computer or cell phone. The goal of the ARS is to engage the audience, its greatest value is enabling the coalescence of instantaneous feedback from in-person and/or remote audience members. Using a video conferencing application combined with the FC pedagogy, a lecturer can facilitate an active learning session where students in their remote locations can respond to questions via an ARS. In the case of Poll Everywhere, this can be instantaneously revealed in the PowerPoint presentation. A productive and interactive learning experience no longer requires the students and facilitators to be in the same location.

2.2.3 Covid-19 pandemic effects & remote learning

During the COVID-19 pandemic, FC increased in popularity at our institution. Many faculty created videos at home, consolidating hours of lecture into videos. Some faculty also mapped content to third-party content resources and focused on knowledge curation and application rather than basic content delivery. Interactive FC sessions were easily held throughout the lockdown remotely using both ARS and video communication platforms. In fact, many professors felt that remote FC delivery was superior to in-person because the chat function of the communication platform decreased the barrier to student involvement. While many students may feel intimidated and scared to offer an answer verbally in front of a class of their peers, entering text into the chat on a video conference seemed to be less intimidating and there was a large amount of participation from a wider array of learners.

2.2.4 Technologies employed

Specific technologies employed at our institution would be Panopto to record audio narration to PowerPoint slides, Camtasia to allow for animation of PowerPoint slides, Poll Everywhere as an ARS that could be embedded within PowerPoint presentations, and Webex as a video conferencing platform. These are by no means the only technologies available, and there are multiple free options including such as Prezi for slide preparation and presentation and Slido, Kahoot!, MeetingPulse as ARS's.

2.2.5 Unique challenges of FC

Flipping even a single hour of lecture content can take an extraordinary amount of time. Even if the software and ARS are free, FC can involve a tremendous amount of faculty time which is one of the most expensive resources in healthcare education. One study found that the time required to prepare for a semester-long course increased by 127% when the sessions were all converted to an FC format [27].

When surveyed, there always exists a cohort of learners who do not rate FC highly, particularly in the context of video streaming of third-party resources. With the rise of competing, professionally sourced content made explicitly to align to national US standardized exams, there are students who see FC sessions as an inefficient way to learn. This indicates that multiple, blended teaching pedagogies (active and passive) may reflect the optimal delivery of content and grooming of critical thinking skills required for successful medical education.

2.3 Think-pair-share (TPS)

TPS is a 3-pronged approach that promotes individual, cooperative, and full class input. A question is first posed to students who are given time to think individually about what the answer might be. Students are then asked to confer with their peers (or they can be assigned to a specific peer) to discuss their answers in a pair or small group. Finally, several of the small groups share with the larger group what they think the answer to be. This is an active pedagogy based on social constructivist learning theory.

2.3.1 Practical application & examples

At our institution, we developed an instructional pedagogy that used FC and the TPS learning model. A series of traditional biochemical lectures that included material

mapping to the USMLE Step 1 Exam Content Outline was streamlined and recorded. The videos were made available to students prior to the flipped session. During class, the students answered clinically-focused questions derived from this material via the ARS. First, the students were presented with a question that they answered using PE as individuals with no peer consultation. After the responses were recorded, the same question was posed to the class again, and after "thinking and pairing" with their peers, a second individual response was recorded. Afterward, the instructor revealed the individual (Pre or pretest) and post-collaborative (Post or posttest) responses and opened the question for full class discussion and annotation. The benefit of using an ARS is the availability of immediate poll results; where students see the correct answer and instructors can gauge knowledge gaps and address misconceptions. This type of Just-In-Time Teaching (JiTT) promotes effective use of class time [28]. JiTT involves students through active learning and instructors use teaching time to address areas of misunderstanding identified by the activities.

For TPS, an ideal question is one that displays significant improvement in performance after peer consultation because it represents a point in the session where collective, active learning has the greatest impact. When we studied this at our own institution, we found that the statistically significant questions were application-based questions that required higher-level thinking skills as per Bloom's taxonomy. We found that many of the statistically insignificant questions had high baseline pretest scores and could be labeled as first-order questions. (i.e. "easy" as they utilize lower levels on Bloom's Taxonomy). Collectively, our data showed that our flipped-TPS model led to improved assessment performance through collaborative learning. Further, our survey data revealed a preference for this pedagogy over the traditional lecture model, consistent with the average recorded attendance of 74% [29].

2.3.2 Unique challenges of TPS: how useful is the "share?"

Classically, during the sharing portion of TPS, educators would either ask learners to volunteer their answers or randomly call on a student. When professors allow students to volunteer, it is common practice that a few students may dominate the discussion. Also, in terms of bias, students with same gender identity and from similar cultural backgrounds are more likely to volunteer their answers [30]. When students know that they may be randomly called on, this can be an extraordinary source of stress for individual students and can decrease overall class attendance. Using an ARS rather than relying on an individual share outside of the context of the responses of the entire group diminishes many of these challenges. Finally, during the recent pandemic, when TPS sessions were made remote, students were noted to be more active in the chat than they were when the meetings were in person. It is due to this that the faculty requested that TPS sessions remain virtual and synchronous even as attendance restrictions from the pandemic were lifted.

3. International implications: a broader perspective galvanized by a pandemic

While there is incredible diversity in the final approach to and practice of medicine across the country and world, the foundational knowledge of medicine is rather universal. This allows educators to share their approaches, educational interventions, and adaptations with each other globally. Indeed, we saw this at a possibly unprecedented level during the COVID pandemic. With a need for virtual education, many

well-resourced institutions made this pivot well to minimize disruption of education [31]. Yet others may face obstacles such as limitations in technology, relevantly skilled staff, and funding [32]. Foundational medical education transcends regional and cultural differences such that interventions developed may be shared in free, open access formats - greatly narrowing this gap. Outside of such pressing needs and at a more practical level, we may avoid duplication of efforts in the design and implementation of the same or near-identical educational interventions. Existing, accessible resources may be curated to satisfy the unique population and needs at hand. Accordingly, such efforts may be allocated toward growth and innovation, which are then shared again, further elevating medical educators. Perhaps more satisfying are benefits such as fostering a sense of collaboration in teaching and learning nationally and internationally. Both educators and learners may share their thoughts, views, successful strategies, frustrations, and more with others – creating a community and sense of connection, thereby broadening their views of the practice of medicine to an international stage. Furthermore, such a mindset may be extended into the future practices of today's learners, resulting in an ever richer and more robust professional experience for physicians and care for patients.

4. Remote learning – broader implications

The pandemic has brought us an unprecedented increase and the use of remote learning. While the subject matter itself may be well conveyed via such remote strategies, there are less tangible aspects of medical education that may be lost in the process. In-person learning allows more readily for student socializing, fostering a sense of community. Indeed, without it, we have seen a marked increase in student self-reports of isolation, anxiety, and depression [33]. Those students also report decreased satisfaction with their medical education [33]. In addition to these potentially devastating consequences, there may be evidence that a weak or nonexistent "classroom community" may harm students' preparedness and performance clinically [34]. This community can build students' communication and teamwork skills both formally via targeted educational programming and informally via the natural proceedings of classroom and group work interactions - what may often be referred to as the hidden curriculum [34, 35].

The students' community is not the only one at risk in remote learning, but also those connections between students and educators, which would normally allow for the less tangible benefits of education. Without this, students may find it difficult to establish a mentorship, which has been shown to be necessary for the ideal professional growth of medical professionals [34, 36]. Educators may lose the reward that is feeling the successful engagement of students during an educational session or witnessing the students' growth and graduation to more complex material and roles. Additionally, it may be difficult for faculty to role model appropriate attitudes and behaviors over remote learning modalities [37, 38].

5. Conclusions

In conclusion, TBL, FC, and TPS are active learning pedagogies based on constructivist educational theory. These are well-liked by students, and accessible and trusted techniques to introduce active learning into healthcare education. This chapter explained each of these pedagogies and then gave specific examples of how to

take traditional lecture-based content and evolve it into one of these engaging educational formats. The technology recommended to employ these tactics was discussed, particularly through the lens of the recent Covid-19 pandemic which caused much of foundational graduate medical education to be delivered remotely. Finally, the international implications of being able to deliver content remotely and some of the consequences of remote learning were reviewed.

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Conflict of interest

The authors declare no conflict of interest.

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